HIGH TEMPERATURE MATTER AND GAMMA RAY SPECTRA FROM EXPLODING MICROSCOPIC BLACK HOLES

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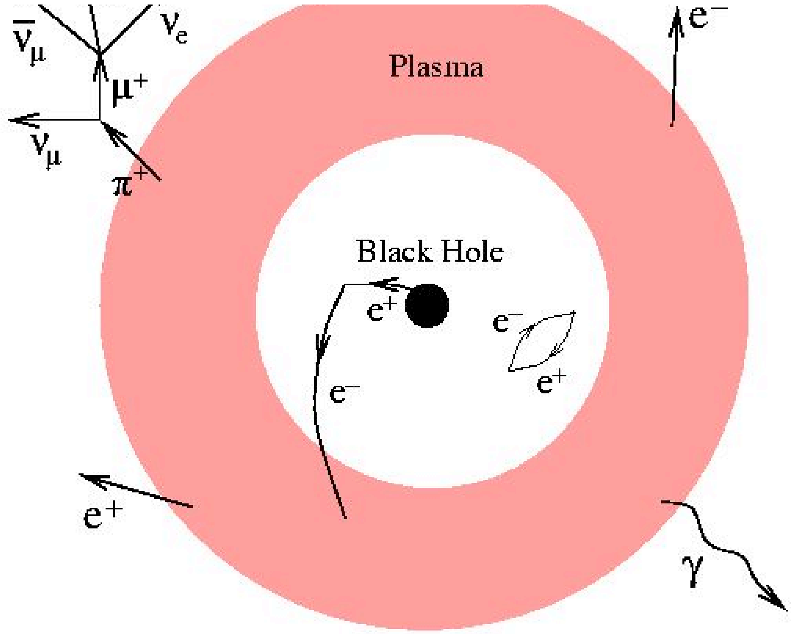
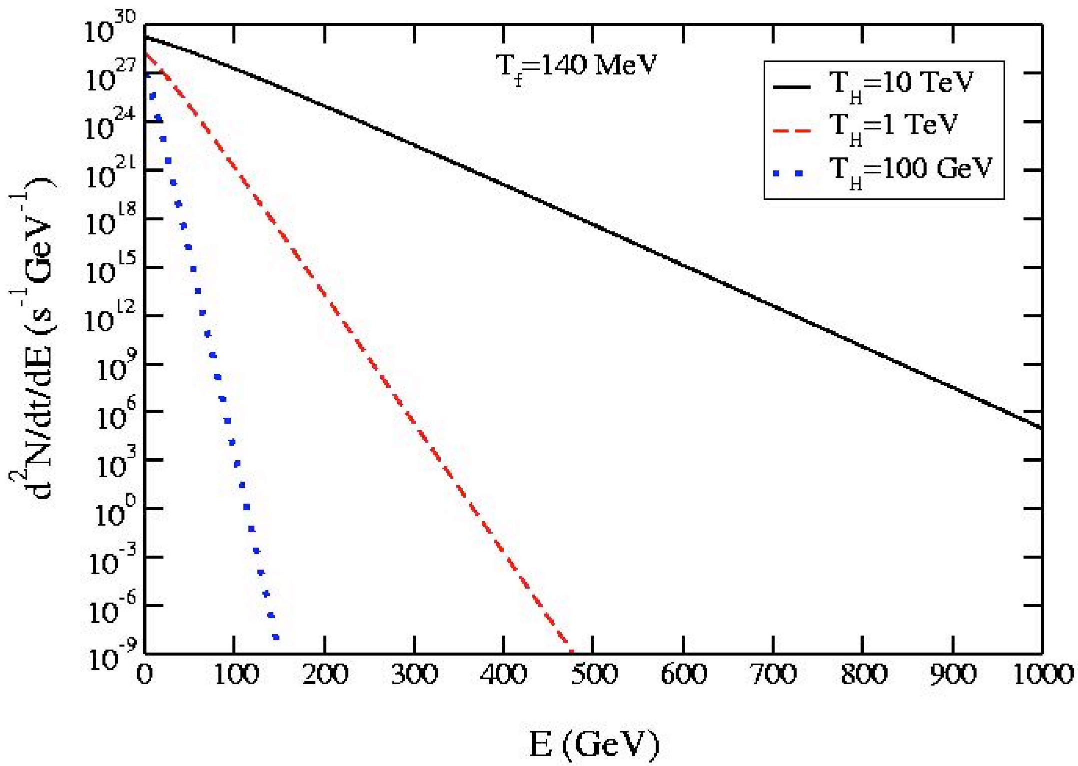
A black hole with mass M radiates thermally (Hawking radiation) with a temperature $T_H = m_{\mathrm{P}}^2/8\pi M$ where m_{P} is the Planck mass. As the black hole radiates, its mass decreases and its temperature increases until T_H becomes comparable to the Planck mass.

At very high black hole temperatures the particles scatter from each other after being emitted, perhaps even enough to allow a fluid description of the wind coming from the black hole. We solve the relativistic viscous fluid equations describing the outflow of high temperature matter created via Hawking radiation from microscopic black holes numerically for a realistic equation of state. We focus on black holes with $T_H > 100$ GeV and lifetimes < 6 days.

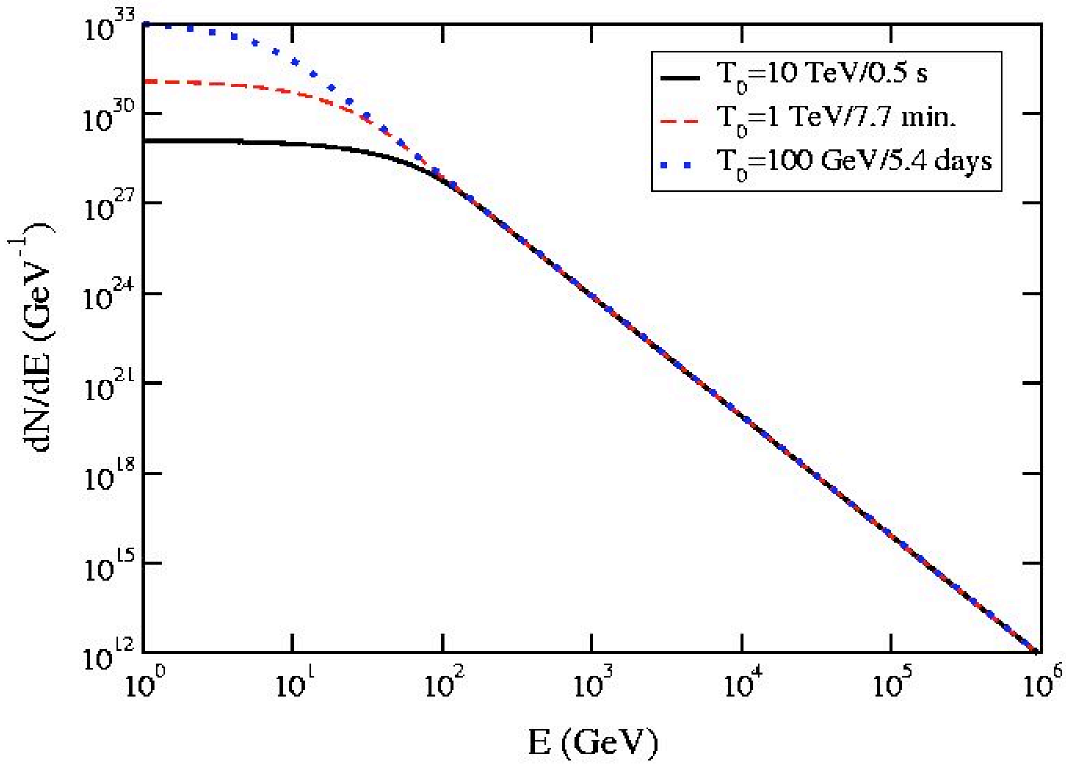


It is found that the relativistic velocity of the fluid $u = \gamma v$, in which γ is the corresponding Lorentz factor, increases like $r^{1/3}$. Eventually the fluid (plasma) expands so rapidly that the particles composing the fluid lose thermal contact with each other and begin to freeze-out. Photons observed far away from the black hole primarily come from one of two sources. Either they are emitted directly in the form of a boosted black-body spectrum (direct photons) or they arise from neutral pion decay.

Instantaneous Gamma Ray Spectrum



The instantaneous spectrum of high energy gamma rays, arising from both direct emission and from π^0 decay assuming a freeze-out temperature T_f = 140 MeV. The three curves correspond to Hawking temperatures (T_H) of 100 GeV, 1 TeV and 10 TeV.



The time integrated gamma ray spectrum for freeze-out temperature T_f = 140 MeV for three initial temperatures T_0. A black hole with a Hawking temperature of 100 GeV has 5.4 days to live, a black hole with a Hawking temperature of 1 TeV has 7.7 minutes to live, and a black hole with a Hawking temperature of 10 TeV has only 1/2 second to live.

The most promising route for the observation of microscopic black holes is to search for point sources in the sky emitting gamma rays of ever-increasing energy. A black hole with a temperature above 100 **GeV** and a Schwarzschild radius less than 10^{-4} **fm** will get brighter on a time scale of **5 days** and then disappear. Such an observation would be remarkable, possibly unique, because astrophysical sources of gamma rays normally cool at late times. This would directly reflect the increasing Hawking temperature as the black hole explodes and disappears. Observation and experimental detection of exploding microscopic black holes will be one of the great challenges in the new millennium.